

# Status of the Accident Sequence Precursor (ASP) Program and the Standardized Plant Analysis Risk (SPAR) Model Development Program

## ASP Program Status

**Analysis of ASP events.** Table 1 of Attachment 2 to this paper provides the status of ongoing, rejected, preliminary, and final ASP analyses. Attachment 2 also summarizes the preliminary and final precursor analyses, and provides a list of events involving cracks in the control rod drive mechanism (CRDM). All precursor analyses from Fiscal Years (FYs) 2001, 2002, and 2003 have been completed, with the exception of the ongoing analyses of the CRDM nozzles at several plants. The analyses of FY 2004 events are also nearing completion, and analyses of FY 2005 events have begun.

**Davis-Besse.** The condition discovered at the Davis-Besse Nuclear Power Station involved degradation of the reactor vessel head and cracking of the CRDM housing. The related precursor analysis also took into account the simultaneous existence of unqualified coatings and other debris that could plug the containment sump, as well as a design deficiency in the high-pressure injection pumps. The simultaneous occurrence of these conditions resulted in the event being classified as a *significant* precursor. The final ASP analysis for this event incorporating internal and external stakeholder comments was issued in March 2005.

**CRDM cracking events.** The staff is currently analyzing conditions involving primary water stress corrosion cracking of CRDM housings. These events involve the discovery of such cracks at 10 plants in FY 2001–2003. This ongoing analysis involves completing the probabilistic analysis of the time-dependent failure frequencies of the CRDM housings. Sensitivity analyses conducted to date show that these cracking events are most likely potential precursors, but not *significant* precursors. Therefore, the staff has included these events in the total count and trending of all precursors (i.e., CCDP or ) CDP  $1 \times 10^{-6}$ ).

**ASP Program status.** The staff plans to complete its analysis of potential FY 2004 precursors by November 2005, and preliminary assessments of all FY 2005 events by April 2006. In addition, the ASP Program will give priority to analyses of potentially high-risk events when such events are identified during NRC inspections or in LERs.

**Investigation of trends and engineering insights.** In SECY-04-012, the staff noted its intent to perform a detailed evaluation of ASP data to investigate the nature of precursor trends and identify insights that can be applied in the NRC's regulatory programs. As part of that effort, the staff has performed a trend analysis study to investigate the apparent decrease in all precursors during FY 1997–1999 and the subsequent increase during FY 2000–2004. Section 2.3 of Attachment 2 to this paper summarizes the study results.

**ASP expert elicitation process.** In 2004, the staff initiated a project to develop a simplified, limited expert elicitation methodology and guideline to meet the needs of the ASP Program. Since Phase 3 calculations of NRC's Significance Determination Process (SDP) are similar to those used in the ASP Program, the expert elicitation guideline is also applicable to the SDP. This procedure will formalize the process used to determine the probability of failure and the operability of equipment for events or conditions that are rare or for which insufficient operational data exist to make meaningful estimates. The new process will involve a formal procedure for seeking expert opinion and judgment that follows the existing expert elicitation

methodology, but is simplified and streamlined as appropriate to the required degree of accuracy and the schedule for completing the ASP analyses. This new expert elicitation guideline is currently being field-tested.

**Review of ASP analyses.** In the past, the staff has issued ASP analyses for internal and licensee review prior to issuing the final analysis. This peer review is typically a 3-month process. For better efficiency, the staff is currently working with internal and external stakeholders on ways to reduce the number of analyses that would undergo peer review. For example, we are looking into eliminating ASP reviews for non-controversial and low-risk events.

### **SPAR Model Development Status**

The SPAR Model Development Program has played an integral role in the ASP analysis of operating events and has evolved over three generations into detailed tools for the analysis of internal events during full-power operations. New SPAR models are currently being developed in response to staff needs for modeling internal initiating events during low-power/shutdown (LP/SD) operations, external initiating events, and large early release frequency (LERF).

The Advisory Committee on Reactor Safeguards (ACRS) informed RES that it had selected the SPAR Model Development Program as one of the three projects that will receive an ACRS review during 2005 regarding "research quality." The staff has engaged in several discussions with ACRS about this matter, and more are anticipated before the review is completed.

The SPAR Model Users Group (SMUG) is composed of representatives from each organization within the agency's program and regional offices that use risk models in their regulatory activities. The SMUG meets regularly to provide technical guidance for the SPAR Model Development Program, consistent with the approved Integrated SPAR Model Development Plan. In accordance with that plan, which conforms to the modeling needs that SMUG members and their management identified for performing risk-informed regulatory activities, the staff completed the following activities in model and method development since the previous report.

#### ***SPAR models for analysis of internal initiating events during full-power operation***

- Developed enhanced Revision 3 SPAR models in response to an NRR user need. This effort involved (1) performing a cut set level review against the respective licensee's plant PRA to each of the Revision 3 SPAR models for the 61 plants that were not pilot plants in the Mitigating Systems Performance Index (MSPI) Development Program, and (2) incorporating into the Revision 3 SPAR models the resolution of the PRA modeling issues that were identified (a) during the onsite quality assurance (QA) reviews of the Revision 3 SPAR models, (b) during the MSPI pilot program reviews, and (c) based on feedback from model users.
- Completed an improved, updated loss of offsite power/station blackout (LOOP/SBO) module, which was then incorporated into each Revision 3 SPAR model.
- Developed an automated process that allows the incorporation of input data into all 72 Revision 3 SPAR models in a relatively short period of time compared to the previous method employed. This new process was then used to update the basic event (component unreliability and unavailability) and initiating event data used in the Revision 3 SPAR models with values that reflect current plant performance.

### ***SPAR models for analysis of internal initiating events during low-power and shutdown (LP/SD) operation***

- Completed an interim LP/SD SPAR model for Davis-Besse and sent the model to the licensee for review. The staff has now completed 11 LP/SD SPAR models.
- The staff is currently working to resolve a potential conflict of interest issue with our contractor at Idaho National Laboratory (INL). Pending resolution of this issue, we plan to complete additional LP/SD models and issue models to licensees in anticipation of onsite QA review.

### ***SPAR models for the calculation of large early release frequency (LERF)***

- Completed the LERF SPAR model for Peach Bottom Atomic Power Station (the lead plant in the second plant class), which is a boiling-water reactor (BWR) 3/4 with a Mark I containment. The staff subsequently sent the model to the licensee in the course of preparing for the onsite QA review of the model against the licensee's Level 2/LERF model.
- Completed the LERF SPAR model for Sequoyah Atomic Power Station (the lead plant in the third plant class), which is a pressurized-water reactor (PWR) with an ice-condenser containment. The staff subsequently sent the model to the licensee in the course of preparing for the onsite QA review of the model against the licensee's Level 2/LERF model.
- The staff plans to issue models for the lead plant in the fifth plant class (BWRs with Mark II containments) and the sixth plant class (PWRs with sub-atmospheric containments) in FY 2006.

### ***SPAR models for the analysis of external events***

- This effort is part of the Risk Assessment Standardization Project (RASP) in support of ASP and SDP Phase 3 analyses. Development is being performed in conjunction with NRR's SDP external events Phase 2 worksheet benchmarking program.
- Completed a feasibility study and issued a report on the feasibility of developing external events models by expanding the existing Revision 3 models. Completed the Limerick SPAR model with external events to demonstrate this feasibility.
- Completed external events SPAR models for the Salem, Callaway, Wolf Creek, and Kewaunee plants.
- The staff is currently working to resolve a potential conflict of interest issue with our contractor at INL. Pending resolution of this issue, we plan to complete additional external events analysis models.

### **Risk Assessment Standardization Project (RASP)**

The primary focus of RASP is to standardize risk analyses in SDP Phase 3, the ASP Program, and the Incident Investigation Program under Management Directive (MD) 8.3. Under this project, the NRC staff is working to complete the following activities:

- Provide on-call technical support to NRR and regional senior reactor analysts. This support will include developing analysis methods or refining existing methods, making analysis-specific enhancements to the SPAR models, and supporting SDP Phase 3 analyses on an as-requested basis.
- Enhance SPAR models and the suite of codes used to manipulate those models (i.e., the Systems Analysis Programs for Hands-on Integrated Reliability Evaluations (SAPHIRE) PRA code and Graphical Evaluation Module (GEM) interface code).
- Document consistent methods and guidelines for SDP Phase 3, ASP, and MD 8.3 analyses of internal events during power operations, internal fires and floods, external events (e.g., seismic events and tornadoes), internal events during Low Power/Shut Down (LP/SD) operations, and LERF sequences.

During the past year, RES has provided increased support on several SDP analyses and risk analyses associated with reactive inspections at the request of regional and NRR analysts. Likewise, regional and NRR analysts have provided valuable support to RES on ASP analysis. RASP support have been provided in the areas of SPAR model enhancements, modeling methodology of unique conditions, development of key analysis assumptions, and calculation of failure probabilities and initiating event frequencies for condition-specific analyses. These information exchanges have reduced the time to complete SDP, MD 8.3, and ASP analyses. In addition, interoffice support contributed to the significant reduction in the number of conflicting results between ASP and SDP analyses.

RES made several enhancements to the Revision 3 SPAR models in accordance with the RASP user need request from NRR. In addition, RES is resolving modeling issues identified during comparisons with licensee PRA models. These activities have improved the fidelity of SPAR models which has increased the use of SPAR models in SDP analyses. Agency-wide use of SPAR models in the analysis of operating events has reduced the time to review draft results of SDP and MD 8.3 assessments, as well as contributed to the reduction of conflicts between SDP and ASP analyses results.

Guidelines for internal events during power operations were completed in April 2005. The deliverable was in the form of a practical, "how to" handbook of methods, best practices, examples, tips, and precautions for applying SPAR models. This handbook was issued for trial use by staff. The handbook has already proved useful to new analysts that recently joined the ASP program. The time and resources needed to train future new analysts will be reduced. The staff began working on guidelines to address external events, LP/SD operations, and LERF. A preliminary completion date for all guidelines is mid-2006.